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High-Early-Strength Concrete with Portland Cement.

M. FREYSSINET'S NEW PROCESS.

M. FREYSSINET, the well-known French engineer, has developed a process by which strengths as high as 5,000 lb. per square inch are reached with ordinary Portland cement concrete two hours after mixing. The process comprises a combination of vibration, pressure and heating, and was described in a paper written by the inventor and read by Mr. T. J. Gueritte at a joint meeting of the Société des Ingénieurs Civils de France and the Institution of Structural Engineers, held in London last month. In the course of his paper the author said he considered he had succeeded in creating a theory and the means of giving it practical application which classed the combination of steel and concrete when treated in accordance with these new methods as an entirely new material possessing properties very different from those of ordinary reinforced concrete.

In 1926 he obtained experimental proof of the delayed deformation of concrete, often referred to as " plastic flow." Concrete placed in an atmosphere of constant humidity exhibits, when loaded, an immediate and partly elastic deformation followed by a deformation which develops slowly in accordance with an exponential function of the time. The slow deformation is partly elastic and reversible, but to a smaller extent and only under certain conditions. He then propounded a theory which showed that this phenomenon, like that known as hygrometric deformation or shrinkage, is a consequence of capillary action, or more exactly of the molecular attractions of which capillarity is a manifestation. This theory is indisputable unless the molecular hypotheses which form the basis of modern physical science are false. Among the curious consequences of

the theory it may be mentioned that concrete may increase in volume when compressed in one direction only. The theory is fully corroborated by observations recorded by the French Commission on Reinforced Concrete (1906).

If the water-cement-ratio is kept as low as possible and if the concrete is sufficiently rich in fine and very fine elements, vibration followed by compression to eliminate the water films created by the vibratory process produces the following results. As soon as setting begins the rate of hardening is very rapid with all kinds of cement, the rapidity of hardening increasing in proportion with the pressure. Pressures ranging from 15 lb. to several thousands of pounds per square inch may be used in practice. With good aluminous cements and suitably selected aggregates it is possible to obtain with concrete a strength of more than 14,000 lb. per square inch two or three hours after the set begins. With Portland cements, slag cements and high-strength cements, results of the same order may be obtained in twelve to twenty-four hours.

Moderate heating accelerates hardening, but if the heating is too intense the strength of the concrete becomes very irregular or may be destroyed. On the other hand, very compact concretes, particularly those obtained by vibration followed by compression, withstand very severe heating without special precautions. If vibrated and compressed concretes are heated to 212 deg. F. hardening becomes almost instantaneous and their quality is permanently improved. A strength of about 5,250 lb. per square inch may be obtained in less than two hours after mixing concrete made with ordinary Portland cement. When heating is discontinued, the increase in strength continues and follows a law very similar to that relating to a non-treated concrete, reaching very high figures which are limited only by the strength of the aggregates used. It is easy to reach from 17,000 to 21,000 lb. per square inch.

As concrete generates heat, raising its temperature towards 200 deg. F. requires very little heat, say, from about 30,000 to 60,000 B.Th.U. per cubic yard. This is easily obtained by steam jackets, the temperature of the concrete rising easily a good deal above that of the steam. To obtain concrete which, even a few hours after mixing, possesses very great strength which increases until it becomes four times that which is generally found sufficient, is in itself a very interesting result. But it is of much greater importance inasmuch as it gives a practical solution to a problem of considerable interest from an economical point of view, but which has proved very difficult to solve, viz. the rational use of the properties of high-tension steel and of concrete of high strength.

At a cost very little greater than that of mild steel special steel is obtainable having a tensile breaking stress about 140,000 lb. per square inch, and an elastic limit which may be raised above 110,000 lb. per square inch by cold drawing. By hardening and annealing, followed by a further cold drawing, it is possible to raise the elastic limit to 185,000 to 198,000 lb. per square inch at a cost of 7*s.* or 8*s.* per ton. As steel with an elastic limit of about 34,000 lb. per square inch is used almost exclusively to-day, it is clear that the ratio $\frac{\text{cost}}{\text{elastic limit}}$ may

be reduced to about one-fifth of its present value, the reduction being still greater in the case of big spans owing to the saving in dead weight which it would procure. But replacing, in an ordinary reinforced concrete structure, mild steel by steel with an elastic limit of 185,000 lb. per square inch would lead to disastrous fissuring of the concrete as soon as the structure was subjected to a load causing steel stresses decidedly higher than those adopted for mild steel, so that the structure does not benefit appreciably from the use of high-tension steel. For example, a pipe reinforced with the same quality of steel with an elastic limit of 210,000 lb. per square inch, but the concrete of which, although made carefully, is ordinary non-treated concrete, would fail as soon as the stress on the steel reaches 19,000 lb. per square inch just as if the reinforcement consisted of ordinary steel. This is because in ordinary reinforced concrete structures the deformation of the concrete is practically equal to that of the steel subjected to the whole of the tension, and the deformation grows in proportion to the stresses, Young's modulus being independent of the special quality of the steel.

The limits of elongation tolerated for concrete are already fully attained with the usual working stresses allowed for mild steel, and consequently the use of high tension steel working in tension adds very little in practice to the strength of a reinforced concrete structure. On the other hand, the improvement obtainable by mechanical means in the compactness of concrete increases the strength in compression up to the strength of the aggregate itself.

As it is possible to use aggregates with a crushing strength of 21,000 lb. per square inch and more, it follows that the ratio $\frac{\text{unit cost of concrete}}{\text{crushing strength}}$ may also be reduced to about one-fifth of its present value. For such concrete the ratio of the elastic limit to the density is very much higher than with ordinary steel, and is nearly equal to the corresponding value for the highest qualities of aviation metals, especially if one takes into account the extra weight of fishplates, links, etc., which does not occur in the case of concrete.

These qualities of low cost and lightness are very poorly used in present-day reinforced concrete. When increasing the compactness of concrete the compressive strength is increased far more than its tensile strength, and this in a measure which depends upon the conditions of fabrication. In addition, its ranges of deformability are considerably reduced. The result is a lowering of the modular ratio $m = \frac{E_s}{E_c}$ with a corresponding rise of the neutral axis, thereby increasing the compression stress in members subjected to bending; this does away with a great part of the advantage which might have been derived from the increased compression strength. Further, in the best designed reinforced concrete structures the resistance in tension is fully as important as that in compression; on tensile strength generally depends the behaviour of the structure as regards shear and torsion stresses and other causes of destruction which calculations generally ignore but which practice must take into account. This is expressed by practical designers when they say that practice renders

necessary a minimum thickness. Consequently it will be seen that the use of concrete of high compactness in ordinary structures increases their strengths in a proportion far inferior to the rate of increase in the compressive strength of the concrete.

Good use of materials of high resistance requires for the steel that the extension of the concrete should be kept within the range of the usual practical limits ; and, for the concrete, that the total tensile stresses should be kept well below the stresses which would rupture the concrete by tension. Theoretically this may be satisfied by abandoning the use of such steel for resisting tensile stresses which would produce elongations that the concrete is unable to follow, and, on the contrary, by inducing in the concrete permanent stresses of opposite sign to those caused by the load ; that is to say, by inducing compression in the zones which the load would tend to stress in tension, and tension in the zones where compression would arise under the load. This result may be obtained by subjecting the reinforcement to tension before the concrete is placed. The bars are gripped near their ends by two temporary anchorages, and the steel is subjected to a known tension by the action on the anchors at one end of jacks held against suitable abutments. The concrete is then placed and allowed to acquire sufficient strength adequately to grip the ends of the bars, after which the jacks are released. The steel reinforcement then tends to shorten, thereby inducing in the concrete a compression equal to the tension which had been imposed on the steel. Another solution is to develop tension in tie rods bearing on concrete already sufficiently hardened. In this way there is developed a double set of permanent stresses identical, but of opposite direction, with those caused in ordinary reinforced concrete members by shrinkage and which are accompanied by troublesome results.

The immediate deformation of the concrete under the induced compression, followed by its delayed deformation and shrinkage, reduces the tension initially given to the steel and the stresses which this tension had set up in the concrete. There must, therefore, be induced in the steel an elongation several times greater than the ultimate shortening of the concrete ; in this way a pre-stressing is secured of which the greater part will remain even after a long lapse of time. For ordinary concrete the shortening may, subject to the conditions in which the shrinkage and the loading take place, reach and even exceed three-thousandths of the length ; this would correspond, as regards the tension of the steel, to a decrease which may exceed 8,500 lb. per square inch.

Very compact concrete considerably decreases the deformations and consequently the reduction of the tension induced. The reduction varies generally between 15,000 and 42,500 lb. per square inch, the latter figure applying only in the case of compressions of the order of 2,900 to 4,300 lb. per square inch. Generally, the author uses tensions calculated to leave in the steel permanent tensions between one-half and two-thirds of the elastic limit of the metal, which has been limited to 113,000 to 127,000 lb. per square inch. It is intended to use much higher elastic limits.

In the author's previous papers on this subject may be found a theoretical study of the effect of the pre-stressing which results from the tension given to the steel. Only a short account of the results is now given. Induced tension in the reinforcement secures: (1) A considerable reduction of the deformation both of steel and of concrete, often in the proportion of 5 to 1. (2) Complete suppression of fissures in the concrete. (3) A decrease in the maximum compression stress in the concrete; this may exceed 60 per cent. in the case of beamless slabs reinforced on one face only. (4) A decrease of the tension produced in the concrete by the shearing stresses, or even its total suppression if the reinforcement is pre-stretched in two directions; in ordinary reinforced concrete the shear reinforcement does not lessen the tension on the concrete; it makes its action felt only after permanent stretching or rupture of the concrete. (5) Considerable resistance against repeated stressing, whereas the resistance of ordinary reinforced concrete members to such actions is very small.

Tests of Poles.

Two telegraph posts 40 ft. long, each fixed over a length of 6 ft. 7 in. from the base, one (*A*) in pre-stressed concrete, and the other (*B*) in ordinary reinforced concrete, were subjected to alternate stressing. Post *A*, five months old, weighed 1,650 lb. with 110 lb. of reinforcement; post *B*, 18 months old, weighed 2,150 lb. with 286 lb. of steel, the quality of the steel in both cases being about the same. Identical posts broke under a pull of about 2,000 lb. for both kinds of posts. During the test for repeated stressing the load applied at the head varied from − 1,000 to + 1,000 lb. at the rate of about eight times per minute. At the beginning the deflection of post *A* was half that of post *B*. After a few hundred alternate deflections post *B* was considerably fissured and it broke entirely after a few thousand, whereas post *A* was subjected to 500,000 alternations without alteration.

The author described the manufacture of concrete pipes by his process, and gave an account of its recent use in stopping the settlement of a wharf at Havre, and in the construction of a bridge girder.

Before the paper was read Mr. R. H. Harry Stanger tested a pipe made by the process. The pipe was about 2 ft. 6 in. long with an internal diameter of 17 in. The pipe was $1\frac{3}{8}$ in. thick, and reinforced with bars equivalent in sectional area to a plate $\frac{1}{16}$ in. thick. The pipe was first vibrated and then subjected to a pressure inducing in the reinforcement a permanent tension of 170,000 to 185,000 lb. per square inch, counteracted by a permanent compression of the concrete amounting to about 7,000 lb. per square inch. When tested the pipe withstood, before leaking, an internal pressure of 1,250 lb. per square inch, which Mr. Stanger stated was ten times that which caused a pipe of ordinary reinforced concrete of the highest quality and of the same dimensions to give way. When fissuring has taken place in a treated pipe and the head has been reduced, the fissures at once close, and a few weeks later the concrete seals the fissures, the pipe being as good as before.

Developments in Concrete Technique.

IT has long been claimed by cement manufacturers that developments in the quality of cement have been in advance of the technique of concrete designers and users. The strength of Portland cement, as exemplified by the limits of standard specifications, has been trebled during the past thirty years, and the rapid-hardening Portland cements of to-day are four or five times as strong as the Portland cements of 1905. The response of the authorities controlling reinforced concrete design to these improvements has been to increase the permissible stresses in concrete by perhaps 50 per cent., although it must be agreed that concrete is now submitted to more drastic conditions than were thought possible in 1905. The cement manufacturer may indeed claim that concrete bridges, domes, telegraph poles, pressure pipes, and even concrete road surfaces have only been made possible by improvements in cement quality, and the impression remains that the development in concrete practice has not kept pace with the progress of cement manufacture.

Engineers have argued that the cement strengths quoted by the manufacturers are tensile tests made under laboratory conditions having but small relation to concrete strengths produced in practice, that the increase in the strength of cement has brought with it disadvantages of increased shrinkage and greater heat development, and that high early strength is only needed in exceptional cases of structural work. Cement manufacturers not only refute these charges but claim that the engineer has not applied scientific methods to concrete production to the same extent as scientific methods have improved the quality of cement. Cement is only one ingredient of concrete, and if sufficient care were given to the grading and cleanliness of the aggregate the water-cement-ratio, and workmanship, the quality of concrete in practice would be more closely related to laboratory tests. It is, for instance, a well-known fact that cement needs something less than 15 per cent. of its weight of water for hydration, and when four to six times this amount is used an obvious defect is created which it should have been the constant study of the engineer and contractor to avoid.

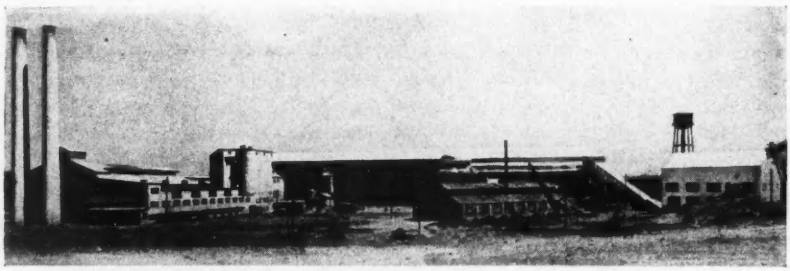
It is therefore with immense satisfaction that manufacturers will welcome the publication by M. Freyssinet of a description of his work, both theoretical and practical (summarised elsewhere in this journal), which has enabled him to produce concrete with compressive strengths up to 21,000 lb. per square inch provided the aggregate itself has this strength. A study of the paper shows that the manufacturers' claims for cement have in fact been too modest. The extremely high strengths obtained by M. Freyssinet, not, it should be noted, in the laboratory, but in practice, have been obtained by a combination of four processes applied to concrete made with the most efficient water-cement-ratio, viz., vibration, compression, heating, and tensioning the steel reinforcement while the concrete is hardening. With vibration followed by a pressure of 2,000 lb. per square inch, M. Freyssinet has obtained a strength of 14,000 lb. per square inch from Portland cement concrete within 24 hours. The natural

development of heat by the cement during setting, which is anathema to some engineers for certain types of work, becomes an advantage because to obtain the required temperature of 212 deg. F. in the concrete, very little external heat—in the form of a steam jacket—is needed. With the heat treatment following the vibration and compression strengths of 4,200 lb. per square inch in two hours have been obtained. One would conclude that high-early-strength cements with their rapid heat development have an advantage in this connection.

As to the causes of these enormous strengths, M. Freyssinet has an interesting theory involving capillarity, surface tension, and molecular attraction, but perhaps the basis of the technique might more simply be described as the use of the minimum proportion of water leading to a concrete of great compactness. Fundamentally the strength of concrete may be ascribed to the strength of the neat cement mortar between the sand particles, and every tester knows the high strength figures obtainable from neat cements if the water percentage is reduced to 17 per cent. or less. The new process is, in fact, reminiscent of the so-called Arnold strength test in which dry neat cement was put under pressure in a mould and allowed to absorb what water it could from a vessel in which the mould stood. This process always gave higher results than could otherwise be obtained in briquette making.

Pre-cast concrete makers have used either compression or vibration for the production of high strength, while heating in the form of steam curing is also a common means of accelerating the development of strength. M. Freyssinet has adapted a combination of the three methods not only to comparatively small pre-cast units but to in situ piles and beams. He is indeed entitled to describe his work as a revolution in concrete practice, for the concrete manufacturer's dream of being able to produce concrete as hard as granite in a few hours has apparently been fulfilled. M. Freyssinet's practical applications have been with reinforced concrete, and naturally the full advantage of the increased concrete strength in combination with steel reinforcement can only be obtained by a modification of orthodox methods. This is done by using high-tensile steel and by putting the reinforcement under tension of 170,000 lb. per square inch before the concrete is placed.

Testing of Cement with Lean Mortars : Standard Sand.—By G. Haegermann. (*Zement*, 1935, p. 695).—In order to obtain a standard sand which eliminates the " packing effect " and gives a plastic mortar with the required water content, several mixtures of sands were tested containing grains of two, three, and eight different sizes. It was found that as good results were obtained with sand consisting of two different grades as with sand with ideal grading. The best mixture consists of two parts standard sand and one part fine sand. The latter consists of 12 per cent. 0—30μ, 68 per cent. residue on the 4,900-mesh sieve, and 5 per cent. residue on the 900-mesh sieve. Differences of $\pm$ 10 per cent. residue on the 4,900-mesh sieve do not affect the strength or the amount of water required.



The New Plant of the National Portland Cement Co.

A New United States Cement Plant.

THE new cement plant of the National Portland Cement Co., at Brodhead, Pa., was opened last year, when one of its two rotary kilns was started. It is claimed that in efficiency and economy of operation this plant is well in advance of the standards of the industry in general. The plant has a capacity of 3,600 barrels daily. Special attention has been given to reducing the number of equipment units without sacrificing flexibility of operation, and only eleven major units are required in the rock-crushing, raw-grinding, clinker-grinding, coal-grinding and kiln departments. The site covers an area of only 22 acres, and the capacity can be trebled without exceeding these dimensions or interfering with the operation of existing equipment. Wherever possible alternative flows for the material are provided to avoid stoppages due to failure of equipment.

Raw Materials.

The deposit of raw materials consists of 300 acres of high-calcium limestone and cement rock. The two kinds of rock are in distinct formations, known as the Jacksonburg and Beekmanstown limestones, but are contiguous and can be worked from a single quarry. The Jacksonburg limestone ranges from low-lime to high-lime content. When it contains from 62 to 75 per cent. calcium carbonate it is locally known as cement rock. When it contains from 75 to 92 per cent. it is known as Jacksonburg cement limestone. The following are average analyses of the two types of stone :

	Jacksonburg cement rock.	Jacksonburg and Beekmanstown cement limestone.
SiO_2	14.68 per cent.	5.56 per cent.
R_2O_3	6.10 ,,	1.85 ,,
$CaCO_3$	75.76 ,,	89.72 ,,
$MgCO_3$	2.86 ,,	2.25 ,,

The cement made from these raw materials shows the following average analysis and strength :

Average analysis.	per cent.	Tensile strength of normal mill-run cement.	lb. per sq. in.
SiO_2	21.48		
Al_2O_3	5.62	1 day	205
Fe_2O_3	2.72	2 days	265
CaO	63.82	3 ,,	328
MgO	2.49	7 ,,	383
SO_3	1.80	28 ,,	495
Loss	0.90		
Free CaO	0.42		

The quarry face is about 40 ft. high and 300 ft. wide. Blast holes are being drilled with 6-in. well drills and they are at present being detonated in single-row shots of 8 holes each. Later staggered multiple-row shots will be made. Atlas 40 per cent. dynamite and electric blasting caps are being used. Secondary drilling of large rocks is being done with jackhammers. A two-stage Fuller rotary compressor rated at 250 cubic feet per minute supplies air at 100 lb. pressure for the jackhammers.

Loading is at present being done by an electric shovel equipped with a 2-cu. yd. dipper. Stone is loaded into 8-cu. yd. standard-gauge steel side-dump quarry trucks and dumped into a 20-ton steel hopper in the crusher building by means of an automatic dumper operated by a single-drum hoist.

Conveying and Crushing Raw Materials.

A pan feeder, 48 in. wide and operating on 20-ft. centres, takes the stone from the hopper and discharges it into the gearless gyratory primary crusher. As the stone at times contains a considerable proportion of clay a water spray has been installed over the hopper to prevent plugging. The excess water is carried off through a flume. A 20-ton overhead crane serves this building. The primary crusher reduces the stone to 8 in. size and under and discharges it to a continuous chain-roller bucket-elevator 36 in. wide and operating on 55-ft. centres, which discharges the stone over a vibrating screen into a 50-ton steel surge-bin divided into two compartments. The material retained on the screen is chuted to one compartment which supplies the two gyratory crushers. The material passing through the screen goes to the second bin compartment, the material from which, together with the product of the crushers—all 1 in. and under—is discharged on the main belt-conveyor. The crusher building has a total of 300 h.p. installed and has a capacity of 300 tons per hour. When the quarry is fully developed it is expected that all the plant requirements can be supplied in a 6-hour day.

The main belt conveyor is 36 in. wide on 300-ft. centres and carries the stone through an enclosed inclined gallery to the corner of the main storage building, where it is discharged on to a 36-in. horizontal distributing belt-conveyor on 180-ft. centres running parallel with the side of the storage building. A travelling

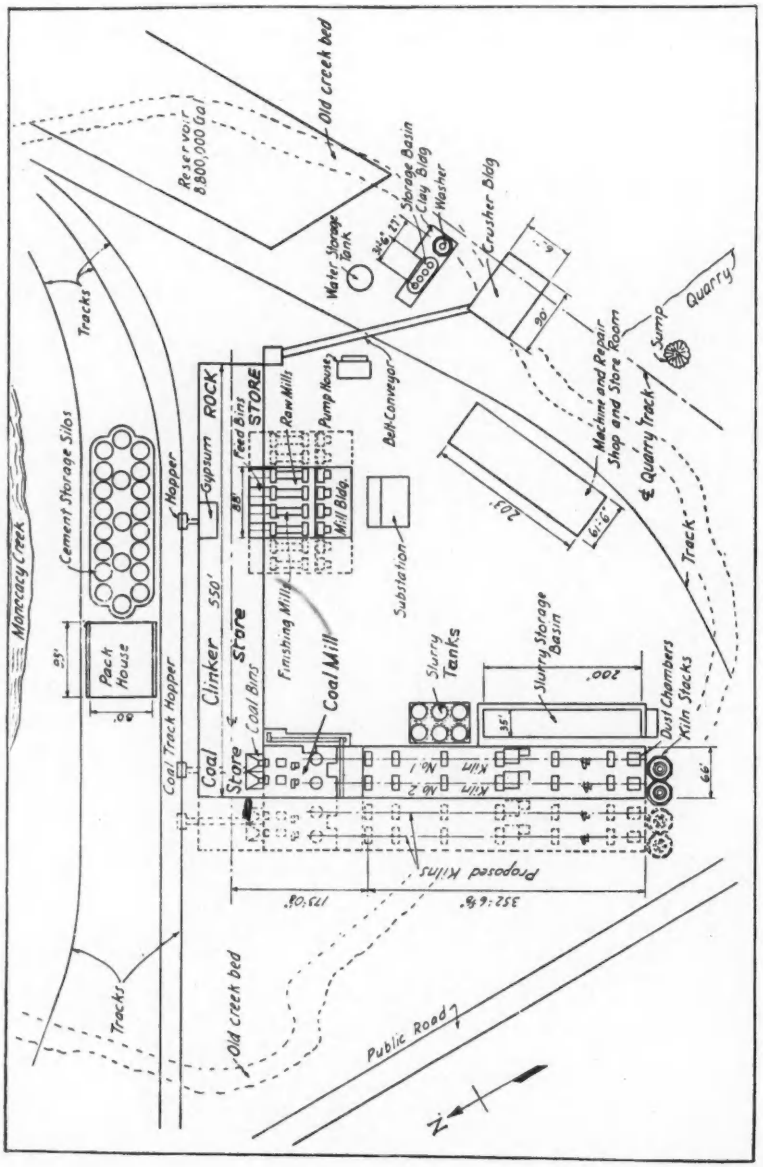

Old creek bed
Reservoir 8,800,000 Gal
Water Storage Tank
Storage Basin
Clay Bldg
Washer
Crusher Bldg
Quarry
Sump
Machine and Repair Shop and Store Room
Quarry Track
Track
Tracks
Cement Storage Silos
Hopper
Gypsum
ROCK
Feed Bins
STORE
Raw Mills
Pump House
Mill Bldg.
Belt Conveyor
Substation
Manasquan Creek
Pack House
Coal Track Hopper
Coal
Clinker
Store
550'
Coal Bins
Finishing Mills
Coal Mill
Slurry Tanks
Slurry Storage Basin
Dust Chambers
Kiln Stacks
Kiln No. 1
Kiln No. 2
Proposed Kilns
175'-0"
352'-6"
Old creek bed
Public Road
N

Fig. 1.

tripper allows the stone to be discharged at any point along the length of the belt or from the end of this belt into the raw-mill feed-bins.

Trucks containing clay will be hauled up the same incline as the stone and by the same hoist, but they will be drawn through the crusher building to the clay-processing building alongside and dumped by an automatic dumper similar to that in the crusher building.

The clay is discharged into an F. L. Smidth 24-ft. diameter wash mill with a mechanical agitator. Any rock settles to the bottom and is drawn off periodically through doors in the bottom of the concrete mill tank. The clay is decanted with a 60 per cent. water content through two spouts to the concrete clay-storage basin, 52 ft. long by 20 ft. wide by 20 ft. deep and equipped with four Smidth mechanical agitators. A small amount of compressed air is also used to prevent stratification of the washed clay. A 3-in. slurry pump transports the clay slip to a Smidth dual-scoop feeder equipped with counters and supplying the raw-grinding mills. Any excess overflows into the storage basin.

The raw material and clinker storage building (Fig. 1) is 550 ft. long by 80 ft. wide, and is divided into sections for the storage of high- and low-lime stone, clinker, coal, and gypsum. The storage capacity for these materials is: stone 200,000 barrels, clinker 200,000 barrels, coal 15,000 tons, gypsum 1,800 tons. A 10-ton overhead crane, equipped with a 3 cu. yd. clam-shell bucket, distributes the materials in storage and handles them to the raw- and finish- and coal-grinding mill-feed bins, all of which abut upon the storage. The four raw-mill feed-bins are of concrete and have a capacity of 400 tons each. Each of the two raw-grinding mills has one bin for high- and one for low-lime stone. Individual Smidth table feeders under these bins proportion the stone to the mills in the desired quantities.

The mill building houses four F. L. Smidth 8-ft. by 36-ft. 4-compartment Unidan mills, two for raw and two for finish grinding. These are similar in every respect, except that the raw mills have smaller motors. Each mill is loaded with 60 tons of grinding media, balls being used in the first two compartments and Cylpebs in the last two. All four mills are driven through Smidth "Symetro" geared speed reducers, the raw mills by 800 h.p. and the finish mills by 900 h.p. motors. The slurry from the raw mills has a moisture content of about 35 per cent. and is discharged into a concrete pump-sump. Two 6-in. centrifugal slurry pumps, one of which is a spare, force the slurry into one compartment of a distributing box which has six outlets discharging into six concrete slurry-blending silos, 22 ft. in diameter and 40 ft. high and with a capacity of 1,400 barrels each. The slurry is agitated by compressed air entering the conical bottoms of the silos.

The materials from a number of silos may, if required, be blended by drawing slurry from them to a concrete pump-sump. A 6-in. pump draws from the sump and feeds the slurry to the other compartment of the distributing box over the silos. This also has six outlets which allow discharge of the slurry to the silo the contents of which are being blended. After the contents of a silo have been

blended the slurry is drawn off by gravity to the main rectangular concrete slurry-storage basin alongside the kiln building. This basin is 200 ft. long, 35 ft. wide and 21 ft. deep and has a capacity of 16,000 barrels of slurry, which is sufficient for four days' operation. The slurry in this tank is agitated by an F. L. Smidth travelling mechanical and compressed-air agitator, having three paddles, which spans the basin and travels its length. Slurry is fed from this storage basin to three 3-in. slurry pumps (one of which is kept in reserve) which deliver it to a single feeder trough over the two kilns. Two Smidth scoop feeders measure the slurry as it enters the kilns. An excess of slurry is always pumped to the feeder trough and the overflow is returned to the storage basin by gravity. These

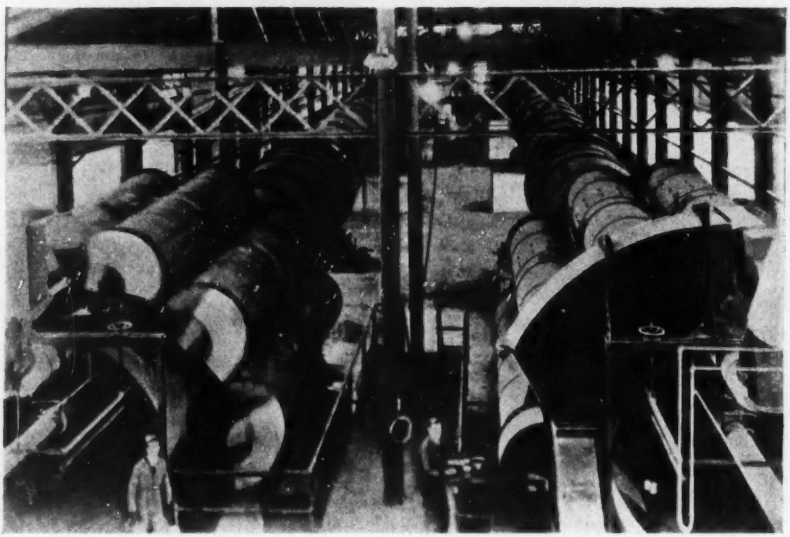


Fig. 2.

feeders are operated by F. L. Smidth patented variable-speed motors operating in synchronism with the kiln motors. When desired, the slurry can be fed directly from the blending silos to the kiln feeder, by-passing the main storage tank, the two 6-in. pumps provided to recirculate slurry to the silos being usable for this purpose. This arrangement allows switching from one type of cement to another without emptying the large tank.

The Kilns.

The two F. L. Smidth kilns (Fig. 2) are 372 ft. long and are divided into three cylindrical sections of approximately equal length, the end sections being 10 ft. and the centre section 9 ft. in diameter. These sections are connected by 6-ft. tapered sections. The kiln shells have a pitch of $\frac{1}{2}$ in. per foot.

Each kiln has six tyres mounted on single oil-lubricated bearing rollers, and

has thrust rollers on the fourth tyre. Smidth counterweighted air seals at the stack ends of the kilns prevent loss of draught at those points. The geared drive-ring is connected to the kiln shell near its centre by spring plates and is driven through gears and a Smidth speed reducer by a 100 h.p. variable-speed direct-current motor having a speed range of from 400 to 1,200 revolutions per minute. On each kiln motor drive shaft is an F. L. Smidth unit for slurry-feed control which generates current to operate the slurry-feed motors, thus maintaining a constant relation between the kiln speed and the rate of slurry feed. Any change in the slurry feed rate is made at the feeder. A solenoid brake and a revolution counter are also connected to the kiln motor, the former to prevent the kiln from rocking when the power is cut off.

The first 80 ft. of the burning zone is lined with 70 per cent. high-alumina brick and the remainder of the kiln is lined with 40 per cent. high-alumina brick. The feed end of the kiln is fitted with a 68-ft. Smidth regenerative chain system to facilitate heating the slurry and the absorption of slurry moisture by the hot kiln gases, to reduce the exit temperature of these gases, and to lower the dust loss. Each kiln has a Smidth steel-plate draught fan, and a Smidth automatic motor-operated louvre damper between the rear housing and the fan intake, both regulated from the kiln-control board.

The kiln gases are discharged at a temperature of about 425 deg. F. through dust chambers into the two kiln stacks, which are off the kiln centre-lines to allow by-passing of the fans for natural draught if necessary. Hoppers and chutes under the dust chambers allow the removal of collected dust. The reinforced concrete kiln stacks are 175 ft. in height with an interior diameter at the top of 8 ft. They have independent self-supporting brick linings throughout their entire height.

The F. L. Smidth kiln-control board is on the burner's platform directly in front of the kilns. Instruments, indicators, recorders, switches, lights, etc., show the draught at both ends of each kiln, the temperature at the feed end, the temperatures of the air (used for drying coal) leaving the discharge end and of the air entering the coal driers and leaving the coal mills, kiln and coal-feed speeds, slurry-feed, fan and coal-mill motors, and the power input to the kilns and accessory equipment ; there are CO_2 and CO plus H_2 indicators, louvre damper controls and indicators, interplant telephone, etc. The kiln fuel consumption is 70 lb. of coal per barrel of cement.

The Unax coolers consist of ten cylinders equipped with chains to agitate the clinker and assist in dissipating their heat. These are in a single circular row parallel to the periphery of the kiln. The clinker leaves the kiln at a temperature of about 2,800 deg. F. and leaves the coolers at about 300 deg. F. The cooled clinker is discharged from both coolers to a Smidth Skipulter conveyor, 60 ft. long and operating at right-angles to the kiln. A second Skipulter set at right-angles to the first discharges the clinker on to a 30-in. inclined apron conveyor on 60-ft. centres.

A double-roll crusher reduces the clinker to a uniform size and discharges it

into the buckets of a 16-in. enclosed elevator on 35-ft. centres discharging into the storage. The gypsum hopper feeds a 16-in. enclosed bucket elevator on 40-ft. centres, which supplies the gypsum compartment of the storage building.

The bituminous coal used for the kilns is discharged into a track hopper, from which a 24-in. inclined apron conveyor on 25-ft. centres feeds a 75-ton-per-hour " Flex-Tooth " hammer-mill-type crusher. The material then drops on to a 24-in. inclined belt conveyor on 108-ft. centres and discharging into a 16-in. enclosed bucket elevator on 55-ft. centres. This elevator discharges the coal either to the coal section of the main storage building or directly to the coal-mill feed-bins. Coal can be returned from storage to the mill-feed bins by the overhead crane or through openings in the floor of the coal-storage section which feed through gates and spouts to the belt conveyor and elevator described. The two reinforced concrete coal-mill feed-bins have capacities of 100 tons each. Gates and chutes pass the coal to reciprocating and screw feeders on two Tirax combination drying and grinding mills.

Each mill consists of a rotary drier and a two-compartment tube-mill operating on the same axis, driven by the same motor and drive, and connected by a hollow trunnion through which the dried coal is fed to the tube-mill section. Each mill has a rated capacity of 5 tons per hour. The drier section of each mill is 4 ft. 9 in. in diameter and 8 ft. long, the pulverising section being of the same diameter and 16 ft. long. The hot air used in drying the coal is drawn from the kiln hoods at a temperature of about 500 deg. F. and leaves the mills at about 120 deg. F. It is drawn into the mills by two Smidth fans, which also draw the pulverised coal from the mills to two cyclones. The coal is discharged from the cyclones into two steel bins below, each of 20 tons capacity and from each of which the coal is fed by double-screw feeders to the kilns. The air from the cyclones is vented to the fans described and is part of the primary air supplied to the kilns. These feed bins have high-level and low-level indicators which keep the operator informed of the amount of pulverised coal available.

Clinker and gypsum are rehandled by the overhead crane from the main storage building to the three finish-mill feed-bins which have a capacity of 400 tons each. The centre bin is used for gypsum ; it has two compartments and supplies both mills. Each of the outer bins supplies clinker to one of the mills. Four Smidth table feeders supply the desired quantities of clinker and gypsum to each mill. The mills are 8 ft. by 36 ft. four-compartment Unidan mills, identical with the raw mills except that they are driven by 900 h.p. motors.

Separators.

The mills discharge into 18-in. screw conveyors, 46 ft. 9 in. long, which empty into two 18-in. bucket elevators operating on 70-ft. centres. When making ordinary cement the elevators discharge their contents by gravity into a 200-barrel storage bin. When desired, the bucket elevators can discharge into two Smidth mechanical and air separators operating in closed circuit with the grinding mills. Each separator consists of two units, one similar to the usual air-separator and the other a special type of cyclone dust-collector which

operates in closed circuit with the separator. A Smidth fan built in with the separator acts as a fluffing unit which produces a dust cloud in the separator, and an air lock preceding the separator controls the supply of air. The fine particles of cement in the separator are diverted with the air through a pipe to the inlet side of the cyclone, while the oversize particles drop from the bottom of the separator to the mill for further reduction. An air lock is also provided at this point. The air-floated cement from the cyclone falls by gravity to the storage bin described. There is also an air lock between the bin and cyclone. The outlet pipe of the cyclone is connected to the suction side of a fan which

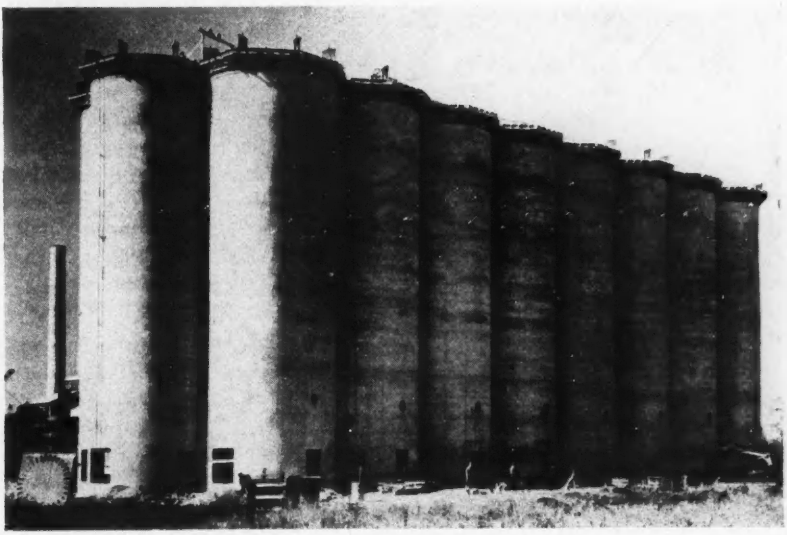


Fig. 3.

assists in drawing fine cement from the separator to the cyclone. The air from this fan enters the bottom of the separator and is recirculated.

Cement Storage.

A Fluxo pneumatic pumping system under the storage bins transports the finished cement through a pipe-line to the cement-storage silos into which the distribution is controlled by valves and feedpipes. This installation consists of two tanks, each about 6 ft. 6 in. in diameter, with an automatic interlock which allows one tank to be filled with cement while the other tank is subjected to air pressure of about 30 lb. to discharge its material through the pipe-line. The cycle of operation is reversed automatically and causes a steady flow of material through the pipe. A feeder under the bin helps to control the feed of cement to this pumping system. Two two-stage rotary compressors each rated

at 750 cu. ft. per minute, supply air at 100 lb. pressure for the Fluxo pumps and for agitation of the slurry. These are direct-connected to 125 h.p. motors.

The storage consists of two parallel rows of eight reinforced concrete silos (Fig. 3) separated by a centre row of five additional silos which are so spaced as to form four additional compartments. Each silo is 25 ft. in diameter and 76 ft. high. As each silo and compartment has a capacity of 10,000 barrels, there is a total storage capacity of 250,000 barrels. A 13-ft. basement below the silos over the loading track houses the cement pumps and compressors. The sixteen silos forming the outer rows are provided with spouts so that bulk cement can be loaded directly into railway trucks. Each spout has a cut-off valve which can be controlled from the truck or from ground level. Air jets inside the silos ensure a steady flow of cement to these spouts and to the pump feed openings.

Three 7-in. Fuller-Kinyon type H pumps are mounted on carriers running on tracks under the three rows of silos. These can be moved so as to take cement from any silo or compartment through 33 openings and convey it to two bag-packer feed-bins in the adjacent pack-house. The cement transport lines are also arranged so that cement can be transported from one silo to another. Three 500 cu. ft. per minute single-stage rotary compressors in the silo basement supply air at about 40 lb. pressure for these pumps, for air agitation of the cement, and for general use in the pack-house. These are driven by 75 h.p. direct-connected motors.

Packing.

Each of the two steel feed-bins in the pack-house has two compartments with a capacity of 400 barrels each and discharges through a Smidth air-agitated feeder to one of the two Fluxo bag-packers. Each of these machines consists of a cylindrical supply tank on which are 12 filling spouts with weighing mechanisms. The tank rotates slowly about its vertical axis and the starting and the flow of cement and the discharge of the filled bags are automatic. The sole duty of the attendant is to slip a bag on each spout as it passes him. Each packer is said to have a capacity of 1,500 to 1,600 bags per hour. Sacks of cement are discharged from the packers by short slat conveyors to two Smidth motor-operated and motor-driven portable belt conveyors, 24 in. wide by 25 ft. long, mounted on wheels. These take them into the trucks on both sides of the building for stacking. Each of the four packer-feed compartments has high-level and low-level bin signals so that the men are kept informed of conditions.

Each packer is connected to a Smidth bag-type dust-collector which returns the collected cement to the packer feed-bins. Under each packer is a small Fluxo pump which returns spilled cement to the feed-bin. A 4,000-lb. elevator carries the sacks, etc., to and from the second and third floors of the pack-house. On the second floor is a bag-cleaning wheel connected to a dust-collector with a fan on the floor above.

Dust Collecting

Dust is controlled by the enclosure of all possible equipment. Dust-collectors are installed in various departments. A collector alongside the crusher building

is connected to the crushers and stone elevator. Smidth collector units serve the two finish-grinding mills and other equipment in this department. In the pack-house two Smidth collectors serve the bag-packers and a collector with a fan is connected to the bag-cleaning wheel.

Power.

The initial installation is estimated to require approximately 4,000 kva., and the final plant 7,500 kva. Power is supplied over two circuits at 33 kv. Ultimately three 2,500-kva. transformers will be required, but two, operating open delta, are sufficient for the present load requirements. From the 2,300-volt switches power is distributed to the kiln building (900 kva.), mill building (450 kva.), packing department (450 kva.), and raw rock department (750 kva.).

The main switchboard consists of 26 panels, and includes blank panels for the control of various equipment, so that the controls for each group will be together. The switchboard operator has control of all circuits leaving the substation, and, in addition, the starting and control of the large grinding mills and the motor-generator sets. In order to eliminate the use of a storage battery and charging set, static rectifiers of copper oxide type are used for control of the oil circuit-breakers. As prolonged interruption of the power supply might result in damage to the kilns, a 400 h.p. oil engine is provided as a stand-by to rotate the kilns while they are cooling and also to agitate the slurry. The oil engine is flexibly coupled to one of the motor-generator sets through a slip coupling.

The entire crushing and transport operation is controlled from a central point. A panel controls the operation of the three crushers, the belt-conveyors, and the dust-collecting equipment, so that the crusher operator has under his control and observation the operation of everything in connection with the crushing and transportation of the raw rock.

Messrs. F. L. Smidth & Co. supplied most of the equipment for the plant, including the kilns, coolers, raw material and clinker grinding mills, coal mills and driers, clinker conveyors, air-separators, slurry and clay agitators, clay wash-mill, bag-packers, cement-transport system, speed-reducers, etc. The Fuller Co. supplied the pneumatic transport system between the silos and the pack-house and all the rotary air-compressors. The foregoing notes are compiled from an article by Mr. W. E. Trauffer in a recent number of *Pit and Quarry*.

Book Review.

Temperatura di Presa dei Cementi. By Luigi Santarella. Milan: Ulrico Hoepli. Price 10 lire. Pp. 79.—This is an account, printed in the Italian language, of experimental work on the development of heat during the setting and hardening of cement. The temperatures reached during the setting and early hardening of concrete cubes of 20 cm. and 40 cm. sides are shown graphically, and the effects of varying the water-cement-ratio, the initial temperature of the concrete, the temperature of curing, etc., are illustrated. Portland cement, pozzolana cement, slag cement, and aluminous cement have been used in the experiments. It is concluded that, in general, the time/temperature curve of concrete does not indicate the strength of the cement used, although with any given cement the time/temperature curve may differentiate between high and low strength. A calorimetric test for heat development of cement during setting is described, together with the necessary cooling-curve calculations.

Studies on Ore Cement or Iron Cement.

By SHOICHIRO NAGAI AND KENJI NOMI.

IN a further report to the Society of Chemical Industry, Japan, the authors report later results of studies on special cements of high iron-oxide content, sometimes known as ore cement (Erzzement) or iron cement (Eisenzement), Kalicrete cement, and Kühl cement, for the purpose of comparison with Portland cement and various mixed Portland cements. The investigations are summarised as follows :

For comparison with special high-iron-oxide Portland cements, one ordinary Portland cement and two mixed Portland cements containing large amounts of silica were prepared from clinker and two kinds of siliceous admixtures by mixing in the proportions of 60 parts of clinker to 40 parts of admixture and grinding in a ball mill, with 2 to 2.5 per cent. of calcined gypsum. These three samples were tested for physical properties, chemical composition, mortar strength, etc. The chemical compositions are shown in Table 1.

TABLE 1.

No. of sample	Cement	Loss on ignition (%)	Insoluble residue (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Free CaO
		%	%	%	%	%	%	%	%	%
266	Portland cement	2.12	0.52	20.94	5.48	2.84	64.82	1.18	1.97	0.72
267	Mixed Portland cement ..	2.78	31.05	48.90	4.42	1.84	38.85	1.26	1.48	0.50
268	Mixed Portland cement ..	4.46	30.76	40.56	6.37	1.64	42.58	1.19	1.52	0.42

The stability of the cements was tested by the Le Chatelier test. The same cylindrical test pieces of hardened neat cement paste, 3 cm. in diameter by 3 cm. high, were tested for compressive strength. In addition, the hardened mass of neat cement was dried in a desiccator, ground to powder, and tested for free lime content and loss on ignition produced by hydration. The results are given in Table 2.

TABLE 2.

Cement		Normal consistency	Le Chatelier test	Compressive strength	Loss on ignition	Free lime
		%	mm.	kg/cm²	%	%
Iron cement ..	IIBb	28	0.5	613	16.8	9.5
	V	28	0.6	311	16.7	8.1
Kalicrete cement	VIa	28	0.2	587	17.9	9.7
Normal Portland cement	246	28.2	1.2	436	18.3	9.5
	266	25	0.2	420	16.0	11.3
Silica mixed Portland cement ..	267	33.5	0.5	313	21.6	5.1
	268	31	0.1	319	19.8	7.2
Blastfurnace slag cement	238	28	0.6	704	20.7	3.2
Neo-solidititt cement	242	32.5	0.9	472	23.4	6.5

It is seen from these results that high iron-oxide special Portland cements set free a little less free lime than normal Portland cement, and that three kinds of mixed Portland cements contained far smaller amounts of free lime, owing to the addition of admixtures, which can be combined with calcium hydroxide.

The temperature rise due to the heat of hydration was determined by a Dewar flask, in which cement paste of normal consistency was allowed to set and harden. The iron cement and Kalicrete cement were found to be suitable as low-heat cements for mass concrete works such as dams.

Tests were made to ascertain the expansion or contraction and strength of specimens cured in water, in 10 per cent. Na_2SO_4 solution, and 10 per cent. NaCl solution for 24 weeks and then boiled in the solutions for 24 hours. The test pieces were mixed in the proportions of 1 : 1 : 2, and were made in a Bauschinger mould measuring 2.25 cm. by 2.25 cm. by 10 cm. Results of the strength tests are given in Table 3.

TABLE 3.

Cement	Curing solution	Bending strength kg/cm²	Compressive strength kg/cm²
Iron cement IIBb	Water	79.3 (**100**)	331 (**100**)
	10% Na_2SO_4	77.8 (98)	324 (98)
	10% NaCl	77.0 (97)	313 (96)
Iron cement V	Water	73.0 (**100**)	463 (**100**)
	10% Na_2SO_4	71.4 (98)	348 (75)
	10% NaCl	73.4 (101)	405 (87)
Kalicrete cement VIa	Water	80.2 (**100**)	365 (**100**)
	10% Na_2SO_4	73.0 (91)	353 (97)
	10% NaCl	72.4 (90)	408 (112)
Normal Portland Cement 246 ..	Water	79.4 (**100**)	489 (**100**)
	10% Na_2SO_4	19.6 (25)	12 (2.5)
	10% NaCl	81.8 (103)	307 (63)
Neo-soliditit cement 242.. ..	Water	81.4 (**100**)	345 (**100**)
	10% Na_2SO_4	9.9 (12)	68 (20)
	10% NaCl	79.4 (98)	435 (126)
Blastfurnace slag cement 238 ..	Water	56.8 (100)	380 (**100**)
	10% Na_2SO_4	(Completely disintegrated)	
	10% NaCl	72.4 (127)	405 (117)

It is seen from these results that the action of 10 per cent. Na_2SO_4 solution is very severe, and that high iron-oxide special Portland cement, iron cement, and Kalicrete cement reach greater strengths than other cements. This resistance of high iron-oxide special Portland cements to the aggressive action of sea water, mineral water, underground water, etc., containing various salts and acids, is an important property of cement for concrete of various civil or public works.

[Previous reports on this subject were published in "Cement and Cement Manufacture," for June and September, 1935.]

Electrically-Hardened Concrete.—(*Polytechnisch Weekblad*, Vol. 29, p. 583, 1935).—Tests on heating concrete electrically by passing alternating current through it by means of embedded electrodes have given good results. Voltages varying from 20 to 50 and from 65 to 120 have been used. The treatment is stated not to harm the concrete.

Rapid Methods of Analysis in the Cement Industry.

IN a recent number of *Zement*, Dr. F. W. Meier describes methods of analysis which are claimed to be accurate and reliable. The methods recommended are as follows :

Raw Materials and Admixtures Insoluble in Acid.

About 0.2 to 0.5 g. of finely powdered silicate is ground and thoroughly mixed in an agate mortar with an equal amount of NH_4Cl and 6 to 8 times that amount of $CaCO_3$. This is transferred to a covered platinum crucible and heated with a small flame at first, until the smell of ammonia has ceased, usually in from 10 to 15 minutes. The flame is then turned full on until fluxing is complete ; this occupies about 40 minutes. The ignition should be carried out with a firebrick or asbestos flue. Prolonged ignition should be avoided, as the mass may melt together and be difficult to dissolve. After cooling, the sintered cake

Fig. 1.

is removed from the crucible by gentle tapping and put into the apparatus shown in Fig. 1. On treatment with hot water the cake rapidly disintegrates and the small pieces left over can be broken up with a glass rod. The material remaining in the crucible is dealt with later. After a short digestion the material is washed two or three times by decantation, each time with 100 cc. of hot water, and the solution is filtered. Most of the material remains in the flask, but as much of the solution as possible should be poured off. From 20 to 25 cc. of perchloric acid diluted to about 40 to 50 cc. are used for dissolving the small residue on the filter and the platinum crucible. The glass rod and the edge of the flask are also rinsed with the solution. The solution of the residue proceeds rapidly and completely if the decomposition of the silicates has been efficient. The solution is heated on a sand bath until white fumes appear, and the heating is then carried on for a further 15 minutes with the condenser attached to the

flask. After it has cooled the mass is digested at least twice at boiling point with 70 to 80 cc. of 10 per cent. HCl, filtered and washed several times with hot HCl and then briefly with hot water, ignited, and weighed. The amount of silicate weighed out should be such as to give 0.2 to 0.3 g. of SiO_2. An excess of water in dissolving the cake should be avoided, as the time is prolonged and the removal of the excess water may cause "bumping." The time can be shortened if the liquid above the silicic acid is filtered off and the residue filtered on a second filter. This method has been tested against the usual method (i.e., decomposition with sodium carbonate, three times evaporated with HCl and heated for one hour at 120 deg. C.), for orthoclase, quartz, kaolin, and mica and the differences vary from $-$ 0.05 to $+$ 0.04 per cent. There is no need to treat the silica with HF, as it is pure. This method reduces the time for an analysis from one day to 3½ to four hours.

Cement Raw Materials.

If lime is to be determined, 1.5 to 2 g. of the finely powdered material are heated to constant weight at 800 deg. C. During heating the contents of the crucible should be stirred several times. The silica is determined by the perchloric acid method already described. If lime is not to be determined, 1 g. of the finely powdered material is mixed with 0.5 g. $CaCO_3$ and 0.5 g. NH_4Cl and slowly heated to 800 to 900 deg. C. After 30 minutes the decomposition is complete. In this case the perchloric acid method can be used directly, as the small amount of potassium perchlorate present is soluble in 10 per cent. HCl. Large amounts, however, partly separate out on cooling and do not go back into solution.

Cements and Blast-Furnace Slags.

One gramme of the finely powdered material is mixed with 10 cc. water in the flask of the apparatus shown in Fig. 1, 15 cc. of perchloric acid added, and the whole heated on a sand bath until white acid fumes appear. Heating is continued for a further fifteen minutes with the condenser attached. The hot solution is then diluted with 70 to 100 cc. of 10 per cent. HCl solution, digested for 5 minutes at 90 to 100 deg. C., and filtered hot. The silicic acid is washed several times with 10 per cent. hot HCl solution, and then briefly with hot water. It is then ignited and weighed. Pure white silica is obtained by this method, and the time required is one hour.

Estimation of Sesquioxides.

After the determination of silica the solution containing free perchloric acid (0.03 to 0.04 g. R_2O_3) is brought nearly to neutrality with ammonia. From 5 to 6 g. of ammonium or sodium acetate and 75 cc. of oxychinolin solution are added, swirling meanwhile; an Erlenmeyer flask is used for this. On heating at 70 deg. C. (this should be checked with a thermometer) the precipitate becomes granular and easily filtered. After cooling, the precipitate is filtered on a Jena glass filter, washed once with cold and finally with hot water, dried for one hour at 110 deg. C., and weighed. Excessive washing should be avoided as the iron oxychinolate ($Fe(C_9H_6ON)_3$) may pass through the filter as a brown colloidal solution. The

iron is determined in an aliquot portion with permanganate or iodometrically on the oxychinolate and subtracted from the total weight of the oxychinolates. The amount of the aluminium oxychinolate $Al(C_9H_6ON)_3$ is determined by difference.

If the silica is not to be determined, but only the lime and sesquioxides, the following method may be used. Half a gramme of the finely powdered and dried (105 deg. C.) material is evaporated with a mixture of hydrofluoric and sulphuric acids and strongly ignited over a bunsen flame until all HF is driven off. The residue is decomposed with sodium bisulphate and the sesquioxides determined by the oxychinolate method.

PREPARATION OF OXYCHINOLIN SOLUTION.—25 g. of 8-oxychinolin are dissolved in 125 cc. of glacial acetic acid, diluted to one litre, and immediately neutralised slowly with 250 cc. of 1 : 5 ammonia solution. The neutral point is reached when the first fine crystals appear. The solution is filtered through a folded filter and diluted with 500 cc. of water.

Action of Carbon Dioxide on Hardened Cement.—By A. Steopoe. (*Zement*, 1935, p. 795).—A study was made of the action of carbon dioxide on porous cement pats made with cement and water, to which a little calcium carbide had been added to swell the cement and make it porous. One set of specimens was kept for four months in damp air free from carbon dioxide, one set for two months in ordinary atmosphere and one month under water, and one set in ordinary atmosphere for four months. At the end of these periods the pats were tested for insoluble residue, acid soluble SiO_2, alkali soluble SiO_2, total SiO_2, and R_2O_3. It was found that the action of atmospheric CO_2 carbonated the hydrated calcium silicates in addition to the calcium hydroxide liberating silica insoluble in acid. The action of CO_2 was stronger with the more porous pats and with the period of contact. This investigation shows that Florentin's method for determining the constituents of concrete by treatment with dilute acids does not give correct results for concretes which have been carbonated, because insoluble silica is liberated during carbonation and may be mistaken for trass or other additions.

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Abstracts from the Foreign Press.

The Nature of the Argillaceous Portion of Cement Raw Materials.—By K. Endell, V. Hoffmann, and E. Maegdefrau. *Zement*, 1935, p. 625.—X-ray studies of German argillaceous materials used in the cement industry show the presence of micaceous clay, montmorillonite, and kaolinite arranged in order of their abundance and quartz. During heating the micaceous clay gives off water at from 200 to 600 deg. C., montmorillonite up to 200 deg. C. (the remaining 5 per cent. water of crystallisation being lost at 500 deg. C.), and kaolin gives up water at 450 deg. C. The relation between the chemical composition of clay and the water content of the cement slurry is discussed. It is shown that the addition of soda to a kaolin clay is uneconomical, but may be useful for a montmorillonite clay. It is noted that most of the works using montmorillonite-clay use the dry process. Works using clay high in kaolin and micaceous clay require under 38 per cent. of water for the cement slurry. The colloidal character of the clay in relation to the speed of filtration and loss of water in the kiln is discussed.

Determining Heat of Solution in Acids of Various Concentrations.—By H. E. Schwiete and A. Pranschke. *Zement*, 1935, p. 593.—The heats of solution of CaO and $Ca(OH)_2$ in hydrochloric acid, of MgO in nitric acid, and of zinc oxide and silver oxide (Ag_2O) in hydrofluoric acid of various concentrations have been determined, and a description of the calorimeter and methods of manipulation is given.

The relation between the heat of solution and the concentration of the solvent has been found to be : (1) Different concentrations of the same acid give different values for the heat of solution ; the differences can amount to several per cent. of the total heat of solution if the concentrations are sufficiently different. (2) For the same acid and substance it is possible to calculate accurately the heat of solution for various concentrations by allowing for the heat of dilution of the acid.

Membrane Filters in the Cement Industry.—(*Zement*, 1935, p. 663).—Membrane filters can be used for the rapid estimation of silica in silicate analyses. The filter consists of three parts, namely, a funnel fitted at its open end with a sintered glass plate (or perforated plate made of porcelain or hard rubber), a membrane filter which fits on this, and a glass cylinder ground flat on its under side and open at both ends which rests on the membrane filter and is held in place by springs. The solution to be filtered is poured into the glass cylinder and suction applied to the funnel. The membrane filters silicic acid rapidly.

Swelling and Shrinkage of Cement.—By G. Mussgnug. (*Zement*, 1935, p. 717).—The swelling during water storage and shrinkage during mixed curing and curing in plain air have been investigated for various cement mortars and concretes. It has been found that the variation in shrinkage of normal cement concretes if properly made is not large. The bending strength is considerably influenced by the type of aggregate used for the concrete.

Recent Patents Relating to Cement.

Portland Cement.

435,870. Rinman, E. L., 14, Ymervägen, Djursholm, Sweden. April 3, 1934.

Silica obtained as a residue when aluminiferous materials such as kaolin, clay, or bauxite, preferably previously roasted, are treated with hydrochloric acid, is dried at a low temperature and then mixed with Portland cement, say in the proportion of 3 parts cement to 1 part silica, to adapt the cement for use in concrete structures below the surface of water.

Refractory Concretes.

432,990. Thornton, A. A., 7, Essex Street, Strand, London.—(Soc. d'Exploitation de Ciments Hydrauliques Refractaires S.E.C.H.Y.R.; 8, Rue Jean Goujon, Paris). March 8, 1934.

A refractory concrete comprises slag cement, chamotte, and calcined bauxite or silica. The slag cement may be that obtained from blast furnaces, and contains less than 30 per cent. of alumina. It may constitute from 20 to 80 per cent. of the mixture. The chamotte is calcined at about 1,350 deg. C. and crushed to a size between that of a pin head and a small pea. In an example, a mixture comprises one part of slag cement of 12 to 15 per cent. alumina content, two parts of calcined bauxite, and two parts of chamotte with a small amount of lime if desired.

Cements and Mortars.

437,719. Kuftner, R., 8, Yorkstrasse, Wiesbaden, Germany. Jan. 29, 1934.

Schist-like materials or materials splitting into flake form are ground with cement clinker or the clinker of other hydraulic binders. In addition, water-soluble alkali silicates, humic acid—e.g. as brown coal—and alum may be ground with the clinker. The schist-like and other materials may be porphyroids, flake porphyry, streaked porphyry, crystalline schist, micacious schist, talc schist, chlorite schist, serpentine schist, bituminous schist, hornblende or gneiss stone. In an example, 700 kg. of clinker, 285 kg. of bitumen-containing schist material, 12 kg. of waterglass having a 1 : 4 proportion of Na_2O to SiO_2, and 3 kg. of alum are milled in a heated ball mill until at least 95 per cent. passes through a 4,900-mesh sieve. Comparative results of tests made on specimens of the resulting material are given.

PATENT.

The Proprietor of British Patent No. 372,044 relating to a "Process for Producing an Improved Lime Suitable for Constructional Purposes" is desirous of securing the full commercial development of the invention in this country either by sale of the Patent outright, or by the grant of licences to work thereunder. Interested parties should communicate in the first instance with Eric Potter & Clarkson, 3, Staple Inn, London, W.C.1.

INDEX TO ADVERTISERS.

Allen, Edgar, & Co.	Back Cover	Krupp-Grusonwerk	vi
Austro-American Magnesite Company	v	Metropolitan-Vickers Electrical Co., Ltd.	—
Babcock & Wilcox, Ltd.	—	Miag Mühlenbau und Industrie, A.-G.	iv
Beard & Fitch, Ltd.	—	New Conveyor Co., Ltd.	—
British Rema Manufacturing Co., Ltd.	—	Newell, Ernest, & Co., Ltd.	—
British Thomson-Houston Co., Ltd.	—	Pearson, E. J. & J., Ltd.	92
Brown, David, & Sons (Hudd.) Ltd.	—	Polysius, G.	viii
Brown, John, & Thos. Firth, Ltd.	—	Prior Fields Foundry Co., Ltd.	—
Davidson & Co., Ltd.	ix	Rolland, John, & Co., Ltd.	vi
Davison, Charles, & Co., Ltd.	vii	Ross Patents, Ltd.	—
Firth, Thos., & J. Brown, Ltd.		Ruston-Bucyrus, Ltd.	—
Frere, R., & F. Evrard	—	Ruston & Hornsby, Ltd.	—
Gebr. Pfeiffer, Barbarossawerke A.-G.	—	Seck Machinery Co., Ltd.	iv
Glover, W. T., & Co., Ltd.	—	Smidth, F. L., & Co., Ltd.	iii
Helipebe, Ltd.	Front Cover	Vickers-Armstrongs, Ltd.	x, xi
Hepburn Conveyor Co., Ltd.	—	Visco Engineering Co., Ltd.	—
Klöckner-Werke	ii		